# Investigating the effective factors in measuring customers' credibility with a combined approach of data mining and multidisciplinary decision making Problem

Received: 11 Jan 2021 Accepted: 03 Mar 2021

Maryam Changiz Delivand [1],Mohammad Bameni Moghadam [2],
Nader Shamami[3], Mohammad Taghipour[4*]

[1] *MasterofIndustrialEngineering,IslamicAzadUniversity,Tehran,Iran (ie.maryamchangiz93@yahoo.com)*

*2 Department of Statistics, Allameh Tabataba'i University, Tehran,Iran (bamenimoghadam@atu.ac.ir)*

[3]*Industrial Engineering-Operations Research and Systems Engineering of Qazvin, Islamic Azad University Qazvin, Iran (nader.shamami@gmail.com)*

[4] *Department of Industrial Engineering, Ooj Institute of Higher Education, Qazvin, Iran (Mohamad.taghipour@srbiau.ac.ir)*

***Abstract*—** *In order to provide loans and facilities, banks must be able to identify and classify their customers based on their ability to repay on time. In this way, banks can achieve the least risk and the highest return. This research tries to provide a better opportunity for banks to identify their customers by using two techniques of data mining and multi-indicator decision making. The statistical population of this study is all customers of 98 branches of the National Bank of West Tehran since 1396 (207104 people) who have deposits of more than ten million Rials. In this research, the effective parameters in credit risk are classified according to their importance and using the multi-criteria decision-making method, the customer's request the facility and the effective factors in measuring the credit of the bank's customers obtained by AHP method include: history of cooperation with the bank. Debt history, loan amount, GPA, customer capital, type of ownership, place of work-living, annual income of the applicant, one-year bank account GPA, loan interest rate, loan term, current capital flow and current capital. Findings show that the average turnover index is the first priority and the applicant's annual income is the last priority.*

***Keywords*—** Credit Risk, Validation, Data Mining, Clustering, Multi-Index Decision Making

## 1. INTRODUCTION

Today, the share of financial and banking services has greatly increased. One of the major problems in the banking, financial and credit systems is credit risk management. The sheer volume of loan facilities to bank customers has challenged banks and financial institutions. The need for financing, planning and risk management is mandatory for banks. Measuring this risk and examining customer credit greatly affects the performance and survival of banks. In this study, data mining techniques and multi-criteria decision making have been used to deal with risk. Banks need to identify their applicants so that they can provide facilities to applicants with more confidence. In many cases, the applicant is not able to pay the principal and interest according to the terms of the contract. Thus, repayments are either delayed or not paid at all [1]. In credit decision making, estimating the amount of risk is an important factor. Therefore, one of the determining factors in reducing credit risk is reviewing the applicant's financial history. The accreditation and rating process for facility applicants is performed by banks to reduce risk. Using data mining, intelligible content and structure can be accessed from hidden data [2].

**- Theoretical foundations and research background**

**- Theoretical Foundations**

Advances in information technology and the evolution of databases have led to the collection of large volumes of data. This data requires analytical tools; Therefore, increasing the volume of data, information extraction and decision-making mechanism is increasing day by day. Accessing new information using database analysis requires information management. Given the growth of databases and the need for managers to analyze data in their decisions, it must be said without a doubt that data mining is the most reliable method for managers. It should be noted that adopting the correct data mining method is

very important. Useful data will be extracted from the data with the help of data mining techniques such as clustering; Therefore, by recognizing the effective factors, the bank's customers can be validated and evaluated so that there is no problem when providing facilities and returning money. Therefore, using the K-Means algorithm, it is possible to rank customers. The clustering technique with a combined data mining approach is necessary in order to discover the hidden knowledge in the data and use it from the point of view of decision makers. Finally, using the multi-criteria decision-making technique, the factors affecting the satisfaction of the bank's customers can be identified.

## 2. BACKGROUND RESEARCH

Abdi Hevelayi et al.[3], studied Predicting Entrepreneurial Marketing through Strategic Planning (Including Case Study).

Haj Abukahaki et al.[4], studiedIdentificaion and prioritization of effective indicators on optimal implementation of customer reiationship management in the insurance industry(including case study).

Taghipour et al.[5], studied Risk analysis in the management of urban construction projects from the perspective of the employer and the contractor.

Rezvani Befrouei MA et al.[6], discussed Identification and Management of Risks in Construction Projects.

Alamdar khoolaki et al.[7], studied Effect of integrated marketing communication on brand value with the role of agency's reputation .

Taghipour et al.[8], studied Analysing the Effects of Phisical Conditions of the Workplace on Employees Productivity.

Baghipour sarami et al.[9], studied Modeling of Nurses' shift Work schedules According to Ergonomics: A case study in Imam sajjad (As) Hospital of Ramsar.

Taghipour et al.[10], studied Supply Chain Performance Evaluation in IN The IT Industry.

Taghipour et al.[11], studied the Study of the Application of Risk Management in the operation and Maintenance of Power Plant Projects

Mahboobi et al.[12], discussed Assessing Ergonomic Risk Factors Using Combined Data Envelopment Analysis and Conventional Methods for an Auto Parts Manufacturer. occupational injuries are currently a major contributor to job loss around the world.

Taghipour et al.[13], studied Assessment and Analysis of Risk Associated with the Implementation of Enterprise Resource Planning (ERP) Project Using FMEA Technique.

Taghipour et al.[14], studied Construction projects risk management by risk allocation approach using PMBOK standard.

Taghipour et al.[15], studied The Evaluation of the Relationship between Occupational Accidents and Usage of Personal Protective Equipment in an Auto Making Unit.

Taghipour et al.[16], studied Necessity Analysis and Optimization of Implementing Projects with The Integration Approach of Risk Management and Value Engineering.

Taghipour et al.[17], studied Evaluating Project Planning and Control System in Multi-project Organizations under Fuzzy Data Approach Considering Resource Constraints.

Taghipour et al.[18], studied Risk assessment and analysis of the state DAM construction projects using FMEA technique.

Taghipour et al.[19], studied the impact of ICT on knowledge sharing obstacles in knowledge management process.

Taghipour et al.[20], studied Assessment of the Relationship Between Knowledge Managment Implementation and Managers Skills.

Taghipour et al.[21], studied Evaluation of the effective variables of the value engineering in services.

Taghipour et al.[22], studied Evaluating CCPM method versus CPM in multiple petrochemical projects.

Soleymanpour et al.[23], studied Mathematical modeling for the location-allocation problem allocation of mobile operator subscribers' affairs' agencies under uncertainty conditions.

Taghipour et al.[24], studied Application of Cloud Computing in System Management in Order to Control the Process..

Abdi et al.[25], studied the relationship between strategic planning with entrepreneurial marketing in the saderat bank of north tehran.

Abbasi & Taghipour,[26], studied An Ant Colony Algorithm for Solving Bi-Criteria Network Flow Problems in Dynamic Networks.

Taghipour et al.[27], studied discussed Insurance Performance Evaluation Using Bsc-Ahp Combined Technique.

Torabi et al.[28], studied Implementation of hierarchy production planning model and its theoretical comparison with manufacturing resources planning.

Taghipour et al.[29], studied Investigating the Relationship between Competitive Strategies and Corporates Performance.

Taghipour et al.[30], studied The identification and prioritization of effective indices on optimal implementation of customer relationship management using TOPSIS, AHP methods.

Asadifard et al.[31], studied A Multi-Objective Mathematical Model for Vehicle Routing Problem Considering the Time Window and Economic and Environmental Objectives Using the Metaheuristic Algorithm Based on Pareto Archive.

Taghipour and Azarian.[32], studied The Impact of Extensive Quality Management on Human Relations (Case Study: Education).

Taghvaee yazdi et al.[33], studied The Impact of Intellectual Capital on Organizational Entrepreneurship (Case Study: Mazandaran Science and Technology Park)

Azarian and Taghipour.[34], studied The Impact of Implementing Inclusive Quality Management on Organizational Trust (Case Study: Education).

Azarian et al.[35], studiedThe Effect of Implementing Total Quality Management on Job Satisfaction (Including Case-Study)

Ghadamzan et al.[36], studied Explain the Relationship Between Intellectual Capital, Organizational Learning and Employee Performance of Parsian Bank Branches in Gilan province.

Taghvaee yazdi et al.[37], studied The Relationship between Implementation Principles of Implementation with Organizational Accelerations, Ethical Leadership and Empowerment of Managers (Case study: Employees of national banks in Sari, District 1)

Hoseinpour et al.[38], studied The Problem Solving of Bi-objective Hybrid Production with the Possibility of Production Outsourcing through Meta-Heuristic Algorithms.

## 3. RESEARCH METHOD

In this study, we try to use the K-Means algorithm to classify the effective parameters in credit risk according to their importance and using the AHP method to identify the factors affecting the credit rating of customers to improve the quality of banks. In fact, this study has investigated the effective factors in measuring the credit of bank customers using data mining methods and multi-criteria decision making.

In general, research objectives can be divided into 3 categories:

1) Investigating the effective factors in the accreditation of bank customers

2) Ranking of bank customers using data mining method (K-Means algorithm) Determining the ranking of agents

3) Affecting customer satisfaction using multi-criteria decision making technique

Society and statistical sample:

The statistical population of the present study is all customers of 98 branches of the National Bank of West Tehran, which in 1396 numbered 207,104 people with deposit accounts over ten million Rials. Sampling method is the stratified random sampling method.

76.76% of the respondents were male and 23.44% were female. 43.23% of the respondents had a diploma, 2.86% had a master's degree, 46.35% had a bachelor's degree and 7.55% had a master's degree or higher.

Identifying effective factors in measuring the credit of bank customers using MADM technique

By quantitative information of customers and considering the range of Table (1) in Expert Choice software, effective factors for measuring the credit of bank customers were identified.

*Table 1. range of evaluation of the factors effective impact on customer credit assessment of the bank*

| **Very much** | **very** | **medium** | **Little** | **Very low** | **Effect rate** |
|---|---|---|---|---|---|
| 5 | 4 | 3 | 2 | 1 | **point** |

According to the total customer information, the set of effective factors in measuring the credit of bank customers by AHP technique was determined according to Table 4.

*Table 2. effective factorsimpact on customer credit assessmentofthebank*

| Rank AHP | Final weight | maximum | At least | Sample | Factors |
|---|---|---|---|---|---|
| 4 | 0.101 | 5 | 1 | 384 | **History of cooperation with the bank** |
| 5 | 0.098 | 5 | 1 | 384 | **History of overdue debt** |
| 6 | 0.067 | 5 | 1 | 384 | **Loan amount** |
| 1 | 0.303 | 5 | 1 | 384 | **Average turnover** |
| 2 | 0.233 | 5 | 1 | 384 | **Customer capital** |
| 3 | 0.198 | 5 | 1 | 384 | **Type of home ownership / life** |
| 11 | 0.06 | 5 | 1 | 384 | **Applicant's annual income** |
| 10 | 0.067 | 5 | 1 | 384 | **The average one- year bank account** |
| 12 | 0.06 | 5 | 1 | 384 | **Loan interest rate** |
| 7 | 0.081 | 5 | 1 | 384 | **Loan term** |
| 8 | 0.077 | 5 | 1 | 384 | **Current capital turnover** |
| 9 | 0.069 | 5 | 1 | 384 | **Current capital** |

According to the information in Table (2), the average turnover of the account with a weight of 0.126 is in the first rank and finally the loan amount with a weight of 0.087 is in the last rank of the effective factors in measuring the credit of the bank's customers. After entering the data from customer quantitative information into the software, the weight of the criteria is calculated separately and using it to form a decision matrix to implement the TOPSIS, ELECTRE and SAW methods, the result of the evaluation of each respondent in this regard as a column of The decision matrix will be considered. The results are obtained according to Table (3).

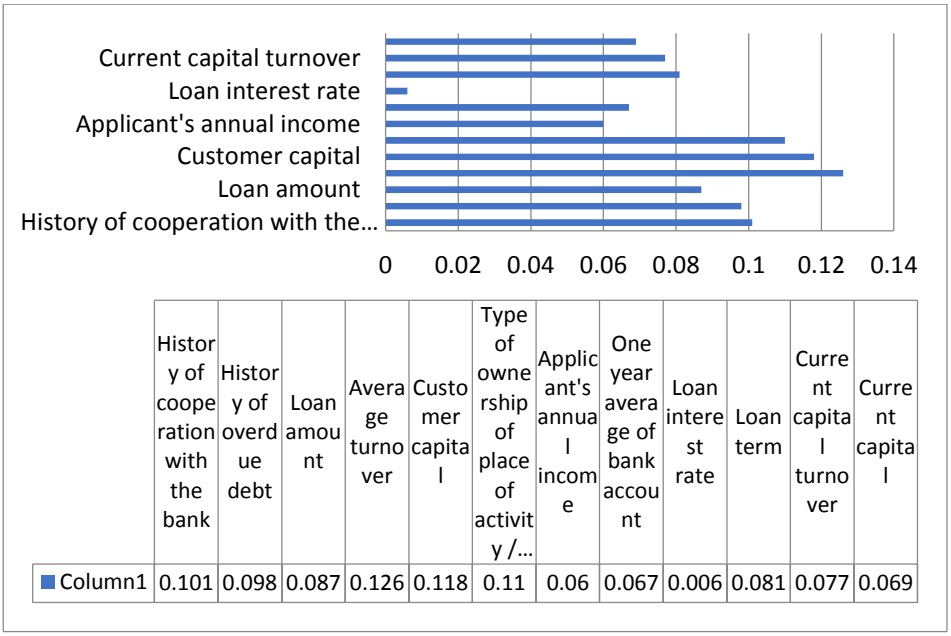


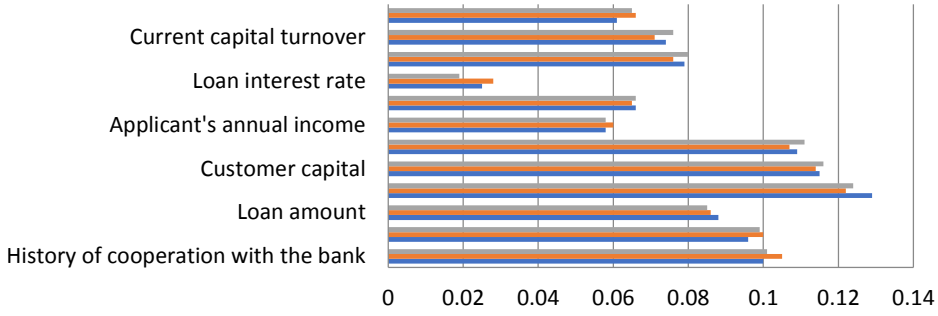

*Diagram 1- Weight of effective factors in measuring the credit of bank customers*

*Table 3.Ratingoffactors effective impact on customer credit assessmentof the bank by TOPSIS ، ELECTRE And SAW*

| T Rank OPSIS | Weight TOPSIS | Rank ELECTRE | Weight ELECTRE | Rank SAW | Weight SAW | Factors |
|---|---|---|---|---|---|---|
| 4 | 10.10% | 4 | 10.50% | 4 | 10.00% | History of cooperation with the bank |
| 5 | 9.90% | 5 | 10.00% | 5 | 9.60% | History of overdue debt |
| 6 | 8.50% | 6 | 8.60% | 6 | 8.80% | Loan amount |
| 1 | 12.40% | 1 | 12.40% | 1 | 12.90% | Average turnover |
| 2 | 11.60% | 2 | 11.80% | 2 | 11.50% | Customer capital |
| 3 | 11.10% | 3 | 10.90% | 3 | 10.90% | Type of home / ownership life |
| 11 | 5.80% | 11 | 6.00% | 11 | 5.80% | Applicant's annual income |

| T Rank OPSIS | Weight TOPSIS | Rank ELECTRE | Weight ELECTRE | Rank SAW | Weight SAW | Factors |
|---|---|---|---|---|---|---|
| 10 | 6.60% | 10 | 6.50% | 10 | 6.60% | The average year- one bank account |
| 12 | 1.90% | 12 | 2.90% | 12 | 2.50% | Loan interest rate |
| 7 | 8.00% | 7 | 6.70% | 7 | 7.90% | Loan term |
| 8 | 7.60% | 8 | 7.10% | 8 | 7.40% | Current capital turnover |
| 9 | 6.50% | 9 | 6.60% | 9 | 6.10% | Current capital |

The information in Table (3) shows the ranking of the effective factors in measuring the credit of the bank's customers by TOPSIS, ELECTRE and SAW methods, the average turnover of the account in the first rank, the customer capital in the second rank and finally the loan amount in the last rank of the effective factors in measuring the credit of customers The bank is located.




| | History of cooperation with the bank | History of overdue debt | Loan amount | Average turnover | Customer capital | Type of ownership of place of activity / life (personal: 1; other: 2) | Applicant's annual income | One year average of bank account | Loan interest rate | Loan term | Current capital turnover | Current capital |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TOPSIS | 0.101 | 0.099 | 0.085 | 0.124 | 0.116 | 0.111 | 0.058 | 0.066 | 0.019 | 0.08 | 0.076 | 0.065 |
| ELECTRE | 0.105 | 0.1 | 0.086 | 0.122 | 0.114 | 0.107 | 0.06 | 0.065 | 0.028 | 0.076 | 0.071 | 0.066 |
| SAW | 0.1 | 0.096 | 0.088 | 0.129 | 0.115 | 0.109 | 0.058 | 0.066 | 0.025 | 0.079 | 0.074 | 0.061 |

*Diagram 2 - Ranking of effective factors in measuring the credit of bank customers by TOPSIS and ELECTRE, SAW methods*

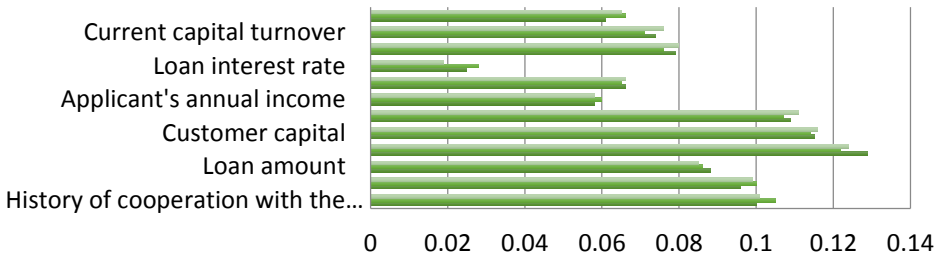
## Identifying effective factors in measuring the credit of bank customers using K-Means technique

### Step 1: Determine the input parameters for Clementine 0.18 software

*Table 4.Rankof the factors affecting the credit assessmentof thebank with approachK-Means*

| RANK | Weight | IMP . | Variables |
|---|---|---|---|
| 4 | 10.10% | 5.001 | **History of cooperation with the bank** |
| 5 | 9.90% | 4.957 | **History of overdue debt** |
| 6 | 8.80% | 4.911 | **Loan amount** |
| 1 | 12.50% | 5.135 | **Average turnover** |
| 2 | 11.90% | 5.130 | **Customer capital** |
| 3 | 11.10% | 5.102 | **Type of ownership of the place of life / activity (2 : other ; 1 : personal )** |

| RANK | Weight | IMP . | Variables |
|---|---|---|---|
| 11 | 6.10% | 3.801 | **Applicant's annual income** |
| 10 | 6.00% | 3.957 | **bank account year- The average one** |
| 12 | 1.50% | 3.088 | **Loan interest rate** |
| 7 | 7.80% | 4.909 | **Loan term** |
| 8 | 7.50% | 4.897 | **Current capital turnover** |
| 9 | 6.80% | 4.822 | **Current capital** |




| | History of cooperation with the bank | History of overdue debt | Loan amount | Average turnover | Customer capital | Type of ownership of place of activity / life (pe... | Applicant's annual income | One year average of bank account | Loan interest rate | Loan term | Current capital turnover | Current capital |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TOPSIS | 0.101 | 0.099 | 0.085 | 0.124 | 0.116 | 0.111 | 0.058 | 0.066 | 0.019 | 0.08 | 0.076 | 0.065 |
| ELECTRE | 0.105 | 0.1 | 0.086 | 0.122 | 0.114 | 0.107 | 0.06 | 0.065 | 0.028 | 0.076 | 0.071 | 0.066 |
| SAW | 0.1 | 0.096 | 0.088 | 0.129 | 0.115 | 0.109 | 0.058 | 0.066 | 0.025 | 0.079 | 0.074 | 0.061 |

*Diagram 3- Ranking of effective factors in measuring the credit of bank customers with K-Means approach*

## Customer clustering based on effective factors in measuring the credit of bank customers

*Table 5- Number of customers in each cluster based on the average turnover of the account*

| | | Customer No. |
|---|---|---|
| Cluster | 1 (upper Credit) | 68 |
| | 2 (Med Credit) | 199 |
| | 3 (Low Credit) | 117 |
| Number of reliable information | | 384 |
| Number of unreliable information | | 0 |

Table (5) shows the number of customers in each cluster based on the average turnover of the account, 68 customers at the high credit level and 117 people with low credit.

*Table 6 -Number of customers in each cluster based on customer capital*

| | | Customer No. |
|---|---|---|
| Cluster | 1 (upper Credit) | 88 |
| | 2 (Med Credit) | 124 |
| | 3 (Low Credit) | 172 |
| Number of reliable information | | 384 |
| Number of unreliable information | | 0 |

Table (6) the number of customers in each cluster based on customer capital, showed that 88 customers of the high level of reliability and 172 people who have low credit .

*Table 7- Number of customers in each cluster based on the type of ownership of the place of activity / life*

| | | Customer No. |
|---|---|---|
| Cluster | 1 (upper Credit) | 111 |
| | 2 (Med Credit) | 109 |
| | 3 (Low Credit) | 164 |
| Number of reliable information | | 384 |
| Number of unreliable information | | 0 |

Table (7) the number of customers in each cluster based on the type of home ownership / life, showed that 111 of the high level of credibility and customers in 164 people who have low credit.

*Table 8 - Number of customers in each cluster based on the history of cooperation with the bank*

| | | Customer No. |
|---|---|---|
| Cluster | 1 (upper Credit) | 134 |
| | 2 (Med Credit) | 107 |
| | 3 (Low Credit) | 143 |
| Number of reliable information | | 384 |
| Number of unreliable information | | 0 |

Table (8) the number of customers in each cluster based on the record of cooperation with the bank, showed that 134 of the high level of credibility and customers in 143 people who have low credit.

*Table 9 -Number of customers in each cluster based on the history of overdue debt*

| | | Customer No. |
|---|---|---|
| Cluster | 1 (upper Credit) | 46 |
| | 2 (Med Credit) | 116 |
| | 3 (Low Credit) | 222 |
| Number of reliable information | | 384 |
| Number of unreliable information | | 0 |

Table (9) the number of customers in each cluster based on the history of debt outstanding, showed that 46 of the high level of credibility and customers in 222 people who have low credit.

*Table 10 -Number of customers in each cluster based on loan amount*

| | | Customer No. |
|---|---|---|
| Cluster | 1 (upper Credit) | 55 |
| | 2 (Med Credit) | 294 |
| | 3 (Low Credit) | 35 |
| Number of reliable information | | 384 |
| Number of unreliable information | | 0 |

Table (10) the number of customers in each cluster based on the loan amount, showed that 55 customers of the high level of reliability and 35 people who have a low credit.*Table 11- Number of customers in each cluster based on loan term*

| | | Customer No. |
|---|---|---|
| Cluster | 1 (upper Credit) | 88 |
| | 2 (Med Credit) | 155 |
| | 3 (Low Credit) | 141 |
| Number of reliable information | | 384 |
| Number of unreliable information | | 0 |

Table (11) the number of customers in each cluster based on the term of the loan, showed that 88 customers of the high level of reliability and 141 people who have low credit.

*Table 12- Number of customers in each cluster based on current capital turnover*

| | | Customer No. |
|---|---|---|
| Cluster | 1 (upper Credit) | 95 |
| | 2 (Med Credit) | 88 |
| | 3 (Low Credit) | 201 |
| Number of reliable information | | 384 |
| Number of unreliable information | | 0 |

Table (12) the number of customers in each cluster based on the flow of funds, showed that 95% of customers a high level of reliability and 201 people who have low credit.

*Table 13 -Number of customers in each cluster based on current capital*

| | | Customer No. |
|---|---|---|
| Cluster | 100 | 100 |
| | 110 | 110 |
| | 174 | 174 |
| Number of reliable information | | 384 |
| Number of unreliable information | | 0 |

Table (13) the number of customers in each cluster based on working capital, showed that 100 of the high level of credibility and customers in 174 people who have low credit.

*Table 14- Number of customers in each cluster based on the one-year average of the bank account*

| | | Customer No. |
|---|---|---|
| Cluster | 96 | 96 |
| | 137 | 137 |
| | 151 | 151 |
| Number of reliable information | | 384 |
| Number of unreliable information | | 0 |

Table (14) the number of customers in each cluster based on the average one -year bank account, showed that 96 customers of the high level of reliability and 151 people who have low credit.

*Table 15 -Number of customers in each cluster based on the annual income of the applicant*

| | | Customer No. |
|---|---|---|
| Cluster | 110 | 110 |
| | 165 | 165 |
| | 109 | 109 |
| Number of reliable information | | 384 |
| Number of unreliable information | | 0 |

Table (15) the number of customers in each cluster based on the annual income of the applicant, show that 110 customers of the high level of reliability and 109 people who have low credit.

*Table 16 -Number of customers in each cluster based on loan interest rate*

| | | Customer No. |
|---|---|---|
| Cluster | 135 | 135 |
| | 108 | 108 |
| | 141 | 141 |
| Number of reliable information | | 384 |
| Number of unreliable information | | 0 |

Table (16) the number of customers in each cluster based on the interest rate of the loan, showed that 135 of the high level of credibility and customers in 141 people who have low credit.

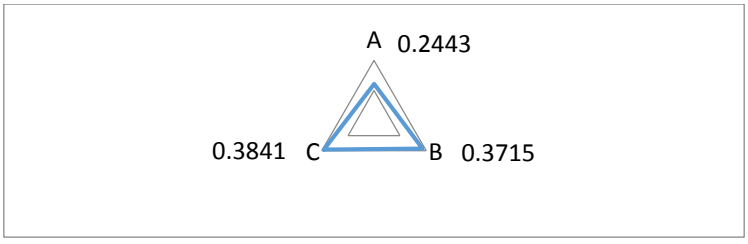



*Diagram 4 - Customers in each cluster based on credit*

37.15% of customers have a credit rating of group B, which have a better credit status than customers of group C and have a medium credit. 38.41% of customers have a credit rating of group C.

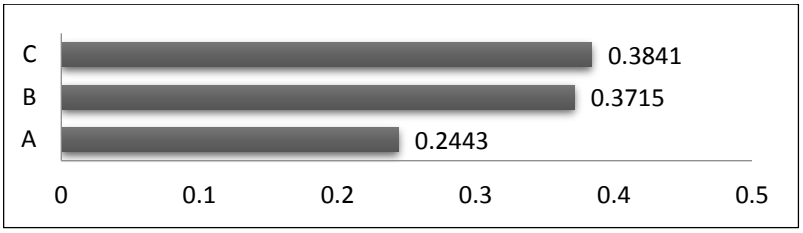



*Diagram 5 - Customers in each cluster based on credit*

In general (according to Charts (4) and (5)) regarding customers, it can be acknowledged that 24.43% of customers are in cluster A or have a credit rating of Group A, which has a high credit status compared to other customers.

## 4. ANALYSIS OF FINDINGS

The results of the analyzes showed;

Regarding demographic indicators of research;

76.76% of the statistical sample was male and 23.44% was female. Also, 43.23% of the analyzed statistical sample have a diploma, 2.86% have a master's degree, 46.35% have a bachelor's degree and 7.55% have a master's degree or higher.

Regarding identifying the effective factors in measuring the credit of bank customers;

According to the total information of customers, the set of effective factors in measuring the credit of the bank's customers by AHP, TOPSIS, ELECTRE and SAW techniques shows, the average turnover of the account in the first place, customer capital in the second place and finally the loan interest rate in the last rank. The credit of the bank's customers is located.

Regarding identifying the effective factors of customer validation with K-Means technique:

The ranking of the effective factors in measuring the credit of the bank's customers with the K-Means approach shows the average turnover of the account with a degree of importance of 5.135 and a weight of 0.125 in the first place and finally the interest rate of the loan with a degree of importance of

3.008 and a weight of 0.015 In the last rank are the effective factors in measuring the credit of the bank's customers.

## 5. CONCLUSIONS AND SUGGESTIONS

In general, customer clustering showed that 24.43% of customers have a credit rating of Group A, which has a high credit status compared to other customers. 37.15% of customers have Group B credit rating and 38.41% of customers have Group C credit rating, which have a lower credit status than Group A and B customers.

For future research related to the present study, it is suggested to study the effective factors in measuring the credit of bank customers using fuzzy logic, customer validation using artificial intelligence algorithm, review and measure the credit of bank applicants using computational intelligence, customer rating evaluation Using ANP network and assessing the credit of the bank's customers using Delphi or fuzzy Delphi technique.

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